

Study on the possibility of the aerosol and/or Yellow dust detection in the atmosphere by Ocean Scanning Multispectral Imager(OSMI)

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Abstract

To examine the detectability of the aerosol and/or Yellow dust from China crossing over the Yellow sea, three works carried out as follows ; Firstly, a comparison was made of the visible(VIS), water vapor(WV), and Infrared(IR) images of the GMS-5 and NOAA/AVHRR on the cases of yellow sand event over Korea. Secondly, the spectral radiance and reflectance(%) was observed during the yellow sand phenomena on April, 1998 in Seoul using the GER-2600 spectroradiometer, which observed the reflected radiance from 350 to 2500 nm in the atmosphere. We selected the optimum wavelength for detecting of the yellow sand from this observation, considering the effects of atmospheric absorption. Finally, the atmospheric radiance emerging from the LOWTRAN-7 radiative transfer model was simulated with and without yellow sand, where we used the estimated aerosol column optical depth ($\tau_{673 \text{ nm}}$) in the Meteorological Research Institute and the d'Almeida's statistical atmospheric aerosol radiative characteristics.

The image analysis showed that it was very difficult to detect the yellow sand region only by the image processing because the albedo characteristics of the sand vary irregularly according to the density, size, components and depth of the yellow sand clouds. We found that the 670-680 nm band was useful to simulate aerosol characteristics considering the absorption band from the radiance observation. We are now processing the simulation of atmospheric radiance distribution in the range of 400-900 nm.

The purpose of this study is to present the preliminary results of the aerosol and/or Yellow dust detectability using the Ocean Scanning Multispectral Imager(OSMI), which will be mounted on KOMPSAT-1 as the ocean color monitoring sensor with the range of 400-900 nm wavelength.

Introduction

A large amount of yellow sand and dust particles is uplifted in the NW Chinese Continent by frontal activities and transported to the Korea peninsula, the Japan and the north Pacific Ocean crossing over the Yellow Sea in springtime. These transported yellow sand particles contribute significantly to the atmospheric turbidity over Korea in spring season(March - May). We observed the yellow sand events three times in this springtime, 1998. Especially, the second event was most severe and lasted very long time from April 14 to 22. The visibility was below 6 km at that time. This phenomenon was caused by the abnormal high and dry temperature due to the EL-NINO formed dry surface and produced much dust storms in China. So, we tried to detect the yellow sand and/or aerosol region by comparing the visible(VIS), water vapor(WV), InfraRed(IR) and composite images of GMS-5 Satellite. In order to elucidate the optical characteristics of aerosols in yellow sand event, We carried out measurements of the solar radiation using the GER-2600 Spectroradiometer during the period of April, 1998. In addition, we simulated the atmospheric radiance using the LOWTRAN-7 radiative transfer model by

inputting the estimated optical depth from the observation.

In this, we describe the results of the image processing and measurement, and discuss the features of the yellow sand in the events. Furthermore we introduce the input data of the LOWTRAN 7 radiative transfer model.

Data and Methods

We select clear day and yellow sand event day to compare the characteristic of the yellow sand in the images, measurement and model simulation.

Solar radiation was measured at the roof of the Meteorological Research Institute(METRI: 37.57° N, 126.97° E) during the April using the GER 2600. The GER 2600 is a light weight, battery operated field portable spectroradiometer with full real-time data acquisition from 350 to 2500 nm with the 1.5 nm resolution from 350 to 1050 nm and 11.5 nm resolution in the range of 1050 to 2500 nm wavelength. We used the 20 m fiber optic cable with 23° Field of View. The GER 2600 measure the atmospheric radiance and produce the reflectance(%) of the target. In order to determine the reflectance of a target, two measurements are required : the spectral response of a reference sample and that of the target material. The reflectance spectrum is then computed by dividing the spectral response of the target material by that of a reference sample. In our case, the reference is the white barium plate assuming perfect reflection and the target is the atmosphere. In addition, we use the column optical depth value calculated from the solar incident radiation using the SPUV-6, which is also measured at METRI.

To simulate the atmospheric radiation using the LOWTRAN 7 radiative transfer model, we must consider the atmospheric effect of the absorption gases. The atmospheric effect was governed by atmospheric constituents such as atmospheric soundings, atmospheric chemical components, and aerosol characteristics. The atmospheric soundings such as Temperature(°C), Pressure(hPa) and H₂O were acquired from Osan(37.06° N, 127.02° E) radiosonde data and vertical ozone data were acquired from Pohang(36.02° N, 129.23° E) ozone-sonde data. The aerosol characteristics(wavelength dependent single scattering albedo, absorption coefficient, extinction coefficient, asymmetric parameter etc.) were provided from the data of d'Almeida's atmospheric aerosol radiative characteristics(d'Almeida, 1991). The vertical aerosol extinction coefficient was obtained from observed aerosol column optical depth in 673nm using the Jang's method(Jang et al., 1997).

Results and Discussion

We analyzed the images of GMS-5 in order to find yellow sand cloud. Yellow sand region was usually identified as the area of patches brighter than the sea and darker than the water cloud in the visible images and it is colder than the land and warmer than the water clouds in the infrared images. Figure 1. shows the VIS, WV, IR and Composite images on April 16, 1998 respectively. The WV images showed the moisture distributions over the upper layer. The black area in the WV image means the dry region and white area means the wet area. The IR images represented the cloud condition of the atmosphere.

In the Fig 1. a strong cold front is located along the north-east coast of the China and some dry area is found at the rear of the cold front (Fig 1a). But, in the VIS and IR images the dry area is showed relatively darker than the cold front clouds. Generally, this obscure area is appeared due to the albedo characteristics of the yellow sand and/or dust. However, the dust clouds were not always found as a clear feature. because its amount, size, depth and density are changed every case of the Yellow sand events and the water clouds covered frequently the source areas.

Second, the solar radiance spectrum measured by the GER 2600 spectroradiometer is absorbed mainly by the H₂O, O₂, O₃ in the visible and near IR wavelength range. The H₂O bands of importance are at

720 and 820 nm ; those of O₂ are 690 and 760 nm; those of O₃ are 450 and 770 nm. If we select the bands suitable to the detection of the yellow sand and/or aerosol, we must choose the wavelength except the absorbing ranges by the atmospheric absorber. In our study, we found that the range of 670 - 680 nm is suitable for the aerosol detection.

Figure 2. shows the measured reflectance(%) in the clear day(April 6) and yellow sand event day(April 16). The reflectance(%) was closely connected with the aerosol and/or dust in the atmosphere. Totally, the reflectance of the yellow sand events day was greater than the clear day both around 12:00 and 14:30 LST. It should be explained the aerosol and/or yellow sand reflected the solar radiation with the 10 % growth around 12:00 LST and over 40 % increasing of reflectance around 14:30 LST in all wavelengths. We could analogize yellow sand was more severe as the time passed from these results. These were also well coincide with the value of column optical depth at 501 and 673 nm. Table 2 shows the column optical depth measured by SPUV-6 and the visibility at that time.

Table. 1 The column optical depth measured at 501 nm and 673 nm in the clear and yellow sand event day, respectively.

| optical depth(τ) | | | τ (501 nm) | τ (673 nm) | visibility (km) |
|-------------------------|------|---------|-----------------|-----------------|-----------------|
| Day and hour | | | | | |
| clear | 4/6 | 12 : 00 | 0.2419 | 0.1305 | 22 |
| | | 14 : 00 | 0.2543 | 0.1386 | 20 |
| yellow | 4/14 | 16 : 06 | 0.8472 | 0.5807 | 4.5 |
| sand | 4/16 | 11 : 50 | 0.9245 | 0.6909 | 7 |

Usually the shorter the wavelength is, the more the column optical depth increases. We focused on the optical depth at the 673 nm belonged to the non-absorption band(670 - 680 nm) from the GER 2600 observations. Then, the optical depth of the yellow sand event day was about four times greater than the clear day, and its visibility was about three times lower than the clear day.

In the future study, we will have the simulation of this observed radiation results using the LOWTRAN 7 radiative transfer model and show the simulated results according to the variation of optical depth.

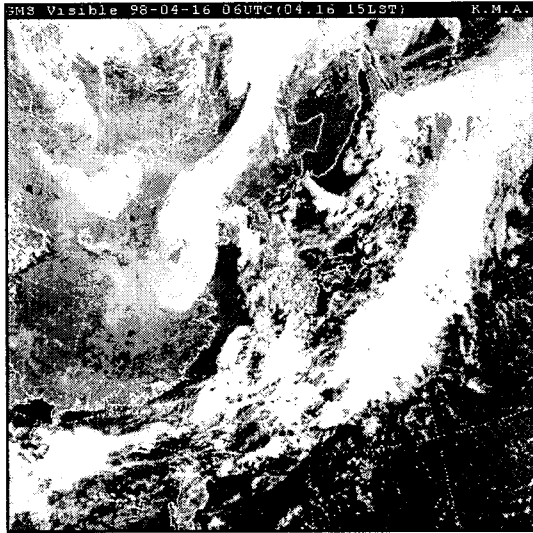
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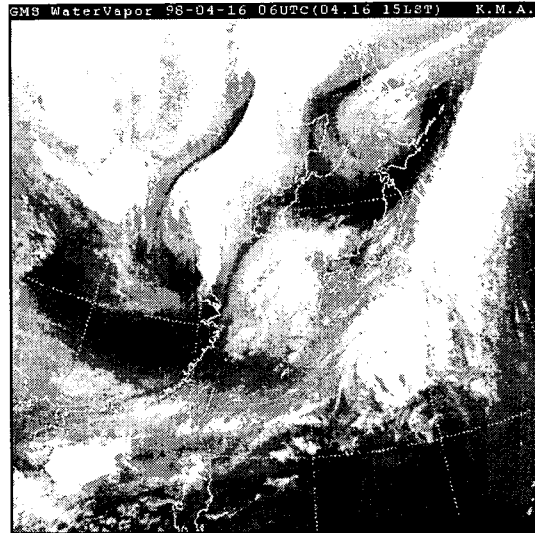
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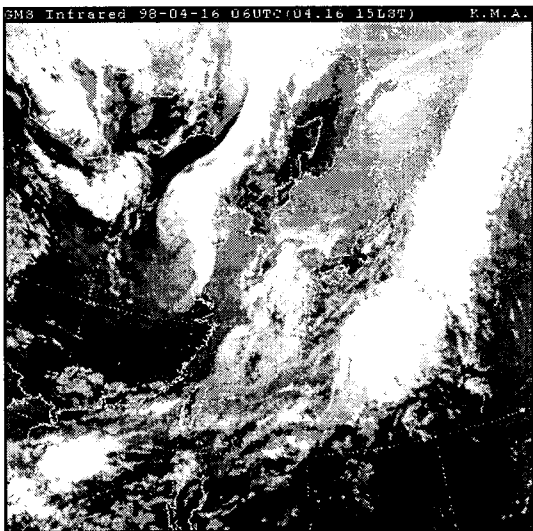
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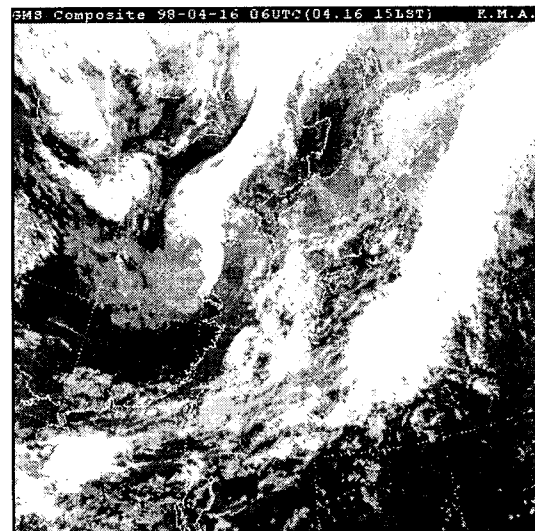
(a) Visible image



(b) WV image



(c) IR image



(d) Composite image

Fig.1 The (a) Visible(VIS), (b) Water Vapor(WV), (c) InfraRed(IR) and (d) Composite images respectively when the yellow sand event occurred at 15 LST April 16, 1998.

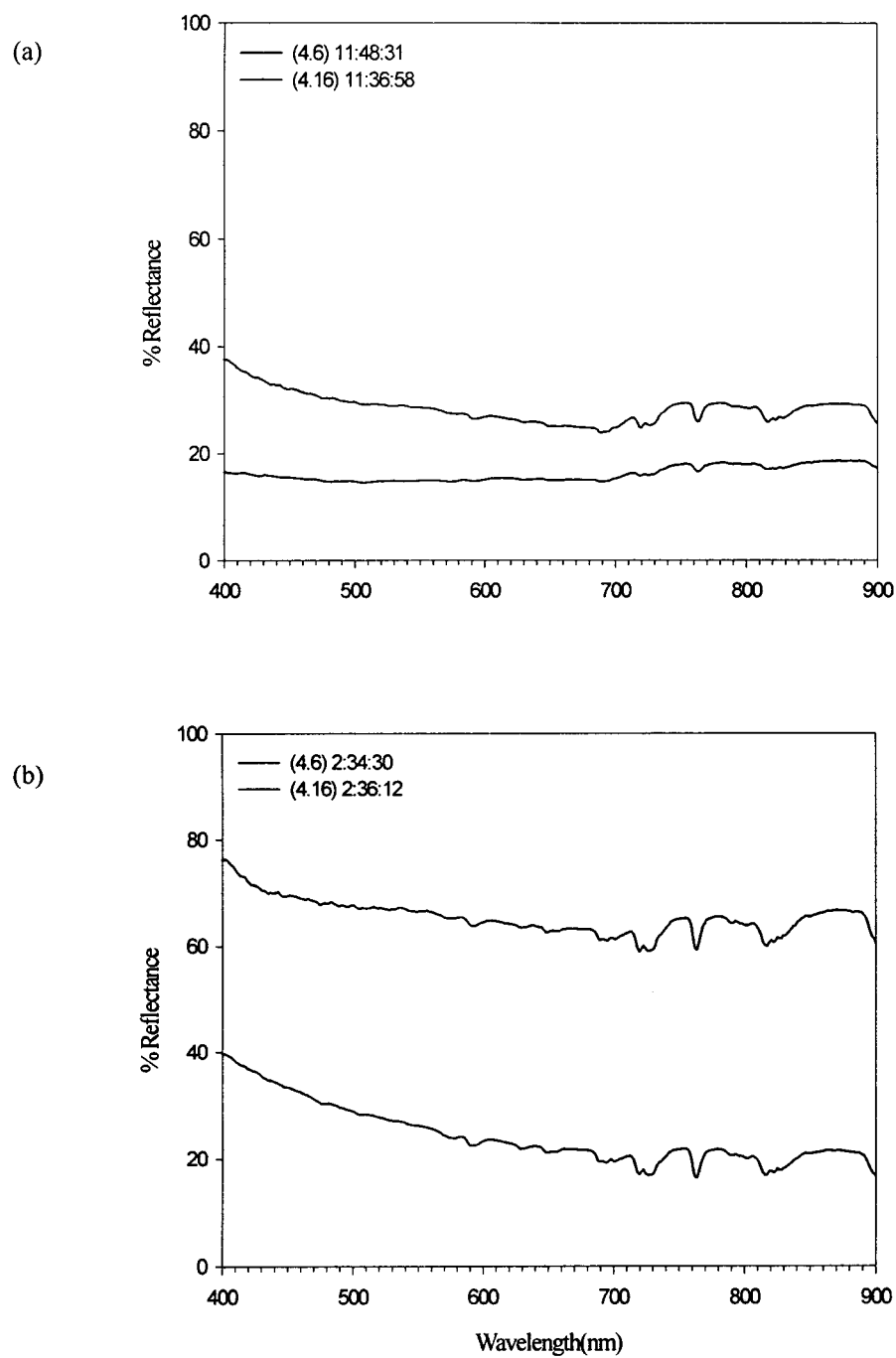


Fig.2 The reflectance(%) in the spectrum band with the range of 400 - 900 nm. (a) and (b) are the reflectance measured around 12:00 and 14:30 LST in METRI. The black and red lines represent April 6 and 16, 1998 respectively.